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(54) Method of manufacturing sintered synchronizing ring

Verfahren zur Herstellung eines gesinterter Synchronisationsring

Procédé de fabrication d'un anneau de synchronisation fritté

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## Description

### Field of Invention

[0001] The present invention relates to a method of manufacturing a synchronizing ring incorporated, for example, into an automotive transmission for synchronously rotating two speed gears to be engaged when changing the speed gears of the transmission so that the two speed gears are engaged smoothly.

### Background of Invention

[0002] A synchronizing ring of such a kind has an annular structural part and a frictional layer. Some synchronizing rings have an annular structural part and a frictional layer formed on the inner circumference of the structural part, some synchronizing rings have an annular structural part and a frictional layer formed on the outer circumference of the structural part, and other synchronizing rings have an annular structural part and frictional layers formed on the outer and inner circumferences of the structural part, respectively. In any one of those synchronizing rings, the frictional layer is brought into frictional engagement with the tapered portions (conical portions) of the speed gears.

[0003] The frictional layer is provided in its working circumference to be in engagement with the tapered portion of the speed gear with a plurality of circumferential grooves of a trapezoidal cross section for cutting an oil film. Top lands are formed between the grooves in the frictional layer.

[0004] If the top lands are abraded, the area of contact between the frictional layer and the tapered portion increases and an oil film is liable to be formed. Consequently, such a synchronizing ring having abraded top lands needs much time for bringing the two speed gears to the same rotating speed.

[0005] Therefore, in most cases, the frictional layer is formed of a highly abrasion-resistant frictional metal easy to machine to form grooves therein, such as iron, aluminum bronze, and high-strength brass.

[0006] In most recent transmissions of a high output capacity, a high pressure is exerted on a synchronizing ring by the tapered portion of a speed gear. Therefore, the frictional layer of the synchronizing ring is abraded rapidly and hence, in some cases, the synchronizing ring is unable to withstand a long period of use. Frictional layers of high-strength brass are particularly rapidly abraded.

[0007] Some synchronizing rings have a structural part and a frictional layer formed of a material containing resin, metal or paper as a base material and bonded to the structural part.

[0008] All those synchronizing rings need to be fabricated by bonding a frictional layer to a structural part. Therefore, the manufacture of those synchronizing rings needs much manhours and high costs.

[0009] A method of manufacturing a synchronizing ring proposed to solve the foregoing problems is disclosed, for example, in Japanese Unexamined Patent Publication No. 223105/1988.

[0010] This previously proposed method of manufacturing a synchronizing ring comprises the following steps.

[0011] First, a self-holding molded ring, which serves as a frictional layer, is formed by compacting a mixture of a sintered powder and a bond or by presintering a sintered powder.

[0012] Secondly, the molded ring is pressed in a support ring (structural part) to form an assembly of the molded ring and the support ring.

[0013] Lastly, the assembly of the molded ring and the support ring is sintered to unify the molded ring and the support ring.

[0014] This method of manufacturing a synchronizing ring has the following problems.

(1) The method requires much time and labor and hence it is difficult to manufacture the synchronizing ring at a low cost because the method needs both the process for compacting a sintered powder and the process for pressing the molded ring in the support ring.

(2) The molded ring i.e., the frictional layer, needs to be formed of metal so that the molded ring may not be broken by a pressure that is applied thereto when the molded ring is pressed in the support ring and the frictional properties and abrasion resistance of the metal must be sacrificed to strength. Consequently, the porosity of the frictional layer is reduced and the frictional layer is unable to secure a satisfactorily high frictional effect.

[0015] US-A-4931117 discloses a method of manufacturing a synchronising ring in which a powder for forming a frictional layer is directly sintered on a pre-formed metallic structural member using a mold. US-A-4931117 suggests employing an adhesive layer between the structural member and the frictional layer.

[0016] The present invention aims to solve the above problems in a simple and efficient manner which nevertheless makes it possible to obtain firm unification of the structural member and the frictional layer.

### Summary of Invention

[0017] Accordingly, in a first aspect, the present invention provides a method of manufacturing a synchronising ring having an annular structural part and a frictional layer formed on the annular structural part, comprising the steps of: filling a mold with a material for the structural part or a material for the frictional layers and compacting the material in the mold; filling the mold with a material for the frictional layer or a material for the

structural part and compacting the material in the mold to unify the structural part and the frictional layer; and simultaneously sintering the unified structural part and frictional layer.

[0018] Further, in a second aspect of the present invention, there is provided a method of manufacturing a synchronising ring having an annular structural part and a frictional layer formed on the annular structural part, comprising the steps of: filling a mold with a material for the structural part and a material for the frictional layer, compacting the materials in the mold; and sintering the materials in the mold by supplying a pulse current through the compacted materials.

[0019] A method embodying the first aspect of the present invention manufactures a synchronising ring by the following processes.

[0020] First, a material for the structural part (or a material for the frictional layer) is filled into a mold and the material filled in the mold is compacted, and then a material for the frictional layer (or a material for the structural part) is filled in the mold and the material filled into the mold is compacted to unify the structural part and the frictional layer mechanically in the mold. The frictional layer is formed integrally with the structural part on the inner or outer circumference of the latter. The structural part and frictional layer thus unified are taken out of the mold and then are sintered in a sintering furnace.

[0021] Then, the frictional layer is cut in a tapered shape (conical shape), and grooves are formed in the frictional layer. The grooves may be formed when compacting the material for the frictional layer in the mold.

[0022] Thus, the synchronizing ring is completed.

[0023] The method according to the second aspect of the present invention manufactures a synchronizing ring by the following processes.

[0024] First, a material for the structural part and a material for the frictional layer are filled in a sintering mold.

[0025] A pulse current is supplied through the structural part and the frictional layer while a pressure is applied to the structural part and the frictional layer to mold and sinter the materials simultaneously. Thus, the structural part and the frictional layer are unified. The frictional layer is formed integrally with the structural part on the inner or outer circumference of the structural part.

[0026] Then, the frictional layer is cut in a tapered shape (conical shape), and grooves are formed in the frictional layer. The grooves may be formed when compacting the material for the frictional layer in the mold.

[0027] Thus, the synchronizing ring is completed.

[0028] The frictional layer of the synchronizing ring manufactured by the method according to the first or second aspect of the present invention is formed integrally with the structural part, and the frictional layer need not be pressed in the structural part. The material for the frictional layer is not presintered and the frictional layer is formed by a single sintering cycle.

## Brief Description of Drawings

[0029]

- 5 Fig. 1 is a schematic sectional views of assistance in explaining a manufacturing method in a first embodiment according to the present invention;  
 10 Fig. 2 is a schematic sectional view of a discharge plasma sintering apparatus; and  
 15 Fig. 3 is a sectional view of a synchronizing ring.

## Preferred Embodiments

[0030] Preferred embodiments of the present invention will be described hereinafter with reference to Figs. 1 to 3.

[0031] Referring to Fig. 3, a synchronizing ring 10 has an annular structural part 11 and a frictional layer 12 formed on the inner circumference of the structural part 11. The structural part 11 and the frictional layer 12 are formed of materials capable of being sintered, respectively.

[0032] Suitable materials for forming the structural part 11 are, for example, a powder of an iron base alloy containing carbon, molybdenum, copper, nickel, and chromium, and a powder of a copper base alloy containing zinc, tin, aluminum, manganese and iron.

[0033] Suitable materials for forming the frictional layer 12 are, for example, powders capable of being sintered, such as, carbon powders, metal powders and resin powders, and fibers capable of being sintered, such as, carbon fibers.

[0034] The synchronizing ring 10 is manufactured by a manufacturing method which carries out a molding process and a sintering process individually (Fig. 1) or a manufacturing method which carries out a molding process and a sintering process simultaneously by a discharge plasma sintering apparatus 30 (Fig. 2).

[0035] A method of manufacturing a synchronizing ring 10 in a first embodiment according to the present invention will be described with reference to Fig. 1. This method carries out a molding process and a sintering process individually.

[0036] A mold 20 employed in this method comprises an annular die 21, a cylindrical core 22, an annular lower punch 23 for forming a frictional layer, disposed between the die 21 and the core 22, an annular upper punch 24 disposed opposite to the lower punch 23, a smaller annular lower punch 25 for forming a structural part, mounted on the die 21, a larger annular lower punch 26 for forming a structural part, mounted on the die 21, a smaller upper punch 27 disposed opposite to the smaller lower punch 25, and a larger upper punch 28 disposed opposite to the larger lower punch 26.

[0037] The larger lower punch 26 and the larger upper punch 28 are used for molding a flange 13 of the structural part 11. The larger lower punch 26 is disposed with its upper end on a level above the upper end of the

smaller lower punch 25.

[0038] The synchronizing ring 10 is manufactured by the following steps.

[0039] At a stage before molding, the lower punch 23 for molding a frictional layer is disposed with its upper end substantially flush with the upper end of the core 22 [Fig. 1A].

[0040] A material for the structural part 11 is filled into a space defined by the lower punches 25 and 26 and the upper punches 27 and 28.

[0041] The larger upper punch 28 and the smaller upper punch 27 are lowered to compress the material for the structural part 11 between the upper punches 28 and 27 and the lower punches 25 and 26 for compacting to form the self-holding structural part 11 [Fig. 1B]. At the same time, splines 15 may be formed in the flange 13. The splines 15 are chamfered, not shown.

[0042] If a portion of the material filled in a space between the larger lower punch 26 and the larger upper punch 28 is compacted (compressed) in a density higher than that of a portion of the material compacted between the smaller lower punch 25 and the smaller upper punch 27, the flange 13 of the synchronizing ring 10 (Fig. 3) has an enhanced rigidity. Usually, the flange 13 is provided with the splines 15 with which a sleeve not shown, i.e., one of the component parts of a transmission, engages. Therefore, it is desirable that the flange 18 has a relatively high rigidity. Those two portions may be formed of materials of different kinds (different compositions), respectively, for the same purpose.

[0043] Subsequently, the lower punch 23 for forming a frictional layer is lowered to form a space between the core 22 and the structural part 11, and a material for the frictional layer 12 is filled in the same space.

[0044] Then, the upper punch for forming a frictional layer is lowered to compress the material for the frictional layer 12 between the upper punch 24 and the lower punch 23 to mold the self-holding frictional layer 12 [Figs. 1C, 1D]. The structural part 11 and the frictional layer 12 are unified mechanically by the pressure applied to the material by the upper punch 24.

[0045] Then, the structural part 11 and the frictional layer 12 thus mechanically unified are taken out of the mold 20, placed in a sintering furnace, and are sintered. When the structural part 11 and the frictional layer 12 are sintered, the materials forming the structural part 11 and the frictional layer 12 are converted into dense, firm solids, particles and molecules of the materials disperse across the interface between the structural part 11 and the frictional layer 12, whereby the structural part 11 and the frictional layer 12 are closely and firmly unified.

[0046] Preferably, the materials to be sintered contain a binder to form compacted parts having a sufficient strength, and the core is treated with a mold lubricant to ensure the satisfactory joint of the materials by sintering and to stabilize the dimensions and density.

[0047] Then, the inner circumference of the frictional layer 12 (Fig. 3) is machined in a tapered shape (conical

shape), and grooves 16 are formed in the inner circumference of the frictional layer 12. Top lands 17 are formed between the grooves 16.

[0048] Thus, the synchronizing ring 10 is completed.

[0049] Although the foregoing method in the first embodiment fills the material for the structural part in the mold and compacts the same, and then fills the material for the frictional layer in the mold and compacts the same, the material for the frictional layer may be filled in the mold and compacted first, and then the material for the structural part may be filled in the mold and compacted.

[0050] A method of manufacturing a synchronizing ring 10, in a second embodiment according to the present invention using a discharge plasma sintering apparatus 30 will be described with reference to Fig. 2. This method carries out a molding process and a sintering process simultaneously.

[0051] Referring to Fig. 2 typically showing the discharge plasma sintering apparatus 30, a sintering mold 36 comprises a guide 32 disposed in a vacuum chamber 31, and an upper punch 33 and a lower punch 34, which are guided for vertical movement by the guide 32. A core 37 is extended through the upper punch 33 and the lower punch 34. The sintering mold 36 is designed taking into consideration the finished shape and dimensions of a product P at an ordinary temperature.

[0052] The upper punch 33 and the lower punch 34 are connected to a power source 35, which supplies a pulse current.

[0053] Materials to be sintered are filled into a space between the upper punch 33 and the lower punch 34, and the upper punch 33 and the lower punch 34 compress the materials.

[0054] A pulse current is supplied through the upper punch 33 and the lower punch 34 for molding and sintering by a plasma the materials that have been compressed.

[0055] The discharge plasma sintering apparatus is capable of sintering the materials at a low temperature in a short time, of more closely and firmly joining together the boundary portions of the structural part and the frictional layer and of forming the structural part and the frictional layer having chamfered portions and keyways in a desired shape and strength without requiring any forging process and any post treatment, such as a heat treatment.

[0056] When using the discharge plasma sintering apparatus, the mold employed in the first embodiment may be employed and disposed as indicated by alternate long and two short dashes lines in Fig. 2. In this case, the material for the structural part and that for the frictional layer can be compacted in different densities, respectively. Some parts of the mold may be replaced with other parts.

[0057] If the method using the discharge plasma sintering apparatus 30 processes metallic materials, the sintering process is carried out in a reducing atmos-

phere or in a vacuum (an evacuated atmosphere) to prevent the oxidation of the metallic materials.

[0058] If the frictional layer is formed by bonding organic carbon with a resin binder, the initial stage of sintering is carried out under a pressure or the atmospheric pressure to suppress the sudden generation of gases.

[0059] Either the method described with reference to Fig. 1 which carries out a molding process and a sintering process individually or the method described with reference to Fig. 2 which uses the discharge plasma sintering apparatus 30 and carries out a molding process and a sintering process simultaneously unifies the structural part 11 and the frictional layer 12 without requiring a process to press the frictional layer 12 in the structural part 11. The material for the frictional layer 12 need not be presintered, and the frictional layer 12 can be formed by a single sintering cycle.

[0060] Although the structural part of the foregoing synchronizing ring is provided with the frictional layer on its inner circumference, the structural part may be provided with a frictional layer on its outer circumference or may be provided with frictional layers on both the inner and outer circumferences thereof. Synchronizing rings of those structures can be manufactured by methods similar to those described herein.

[0061] A mold, not shown, suitable for manufacturing a synchronizing ring having a structural part and a frictional layer formed on the outer circumference of the structural part has a structure constructed by disposing a set of punches corresponding to the set of punches 28 and 26 of Fig. 1 and a set of punches corresponding to the frictional layer forming punches 24 and 23 of Fig. 1 in a diameter greater than that of the set of punches corresponding to the set of punches 28 and 26.

[0062] A mold, not shown, suitable for manufacturing a synchronizing ring having a structural part and frictional layers formed on the inner and outer circumferences of the structural part has a structure constructed by disposing sets of frictional layer forming punches on the inner side and outer side of the set of punches 27 and 25 of Fig. 1, respectively.

[0063] Although the material for the frictional layer, as a rule, is a powder, the material may be a preformed ring, a flexible sheet or a material containing paper or nonwoven fabric of fibers as a base, provided that the material is capable of being sintered.

#### Advantages of Invention

[0064] The manufacturing methods stated in claims 1 and 2, which unify the frictional layer and the structural part without requiring a process of pressing the frictional layer in the structural part, have the following advantages.

(1) A process for compacting a sintered powder and a process for pressing, which are necessary for conventional methods, are unnecessary and hence

the number of processes can be reduced.

(2) The frictional layer may be formed of a material having a high porosity other than metals, and hence the frictional layer having a desired frictional effect can be formed.

[0065] The method stated in claim 2 in particular, carries out a molding process and a sintering process simultaneously by discharge plasma sintering and hence has the following advantages in addition to those mentioned above.

- (1) No mold specially for molding is necessary.
- (2) Sintering can be accomplished at a low temperature in a short time.
- (3) The structural part and the frictional layer can more firmly be unified.

#### Claims

1. A method of manufacturing a synchronising ring (10) having an annular structural part (11) and a frictional layer (12) formed on the annular structural part, said method comprising the steps of:

filling a mold (20) with a material for forming the structural part (11) or a material for forming the frictional layer (12) and compacting the material in the mold;

filling the mold (20) with a material for forming the frictional layer (12) or a material for forming the structural part (11) and compacting the material into the mold to unify the structural part (11) and the frictional layer (12); and simultaneously sintering the unified structural part (11) and frictional layer (12).

2. A method of manufacturing a synchronising ring (10) having an annular structural part (11) and a frictional layer (12) formed on the annular structural part, said method comprising the steps of:

filling a mold (20) with a material for forming the structural part and a material for forming the frictional layer (12);

compacting the materials in the mold; and sintering the materials in the mold by supplying a pulse current through the compacted materials.

3. A method of manufacturing a synchronising ring (10) according to Claim 1 or 2, wherein the density or quality of the compacted material for forming the structural part (11) is varied according to radial positions in the structural part.

4. A method of manufacturing a synchronising ring

(10) according to any one of Claims 1 to 3, wherein the material for forming the structural part (11) is an iron base alloy powder.

5. A method of manufacturing a synchroniser ring (10) according to any one of Claims 1 to 3, wherein the material for forming the structural part (11) is a copper base alloy powder. 5
6. A method of manufacturing a synchronising ring (10) according to any one of Claims 1 to 5, wherein the material for forming the frictional layer (12) is a powder capable of being sintered, such as a powder of carbon, metal or resin. 10
7. A method of manufacturing a synchronising ring (10) according to any one of Claims 1 to 5, wherein the material for forming the frictional layer (12) includes fibers capable of being sintered, such as carbon fibers. 15 20

#### Patentansprüche

1. Ein Verfahren zur Herstellung eines Synchronisationsrings (10) mit einem ringförmigen Bauteil (11) und einer auf dem ringförmigen Bauteil ausgebildeten Reibschicht (12), wobei das Verfahren die folgenden Schritte umfaßt: 25

Befüllen einer Form (20) mit einem Material zum Ausbilden des Bauteils (11) oder einem Material zum Ausbilden der Reibschicht (12) und Verdichten des Materials in der Form; 30

Befüllen der Form (20) mit einem Material zum Ausbilden der Reibschicht (12) oder einem Material zum Ausbilden des Bauteils (11) und Verdichten des Materials in der Form, um das Bauteil (11) und die Reibschicht (12) zu vereinen; und 35

gleichzeitiges Sintern des vereinten Bauteils (11) und der Reibschicht (12). 40

2. Ein Verfahren zur Herstellung eines Synchronisationsrings (10) mit einem ringförmigen Bauteil (11) und einer auf dem ringförmigen Bauteil ausgebildeten Reibschicht (12), wobei das Verfahren die folgenden Schritte aufweist: 45

Befüllen einer Form (20) mit einem Material zum Ausbilden des Bauteils und einem Material zum Ausbilden der Reibschicht (12); 50

Verdichten der Materialien in der Form; und 55

Sintern der Materialien in der Form durch Spei-

sen eines Impulsstromes durch die verdichteten Materialien.

3. Ein Verfahren zur Herstellung eines Synchronisationsrings (10) nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Dichte oder Qualität des verdichteten Materials zum Ausbilden des Bauteils (11) entsprechend radialen Positionen in dem Bauteil variiert wird.
4. Ein Verfahren zur Herstellung eines Synchronisationsrings (10) nach irgendeinem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß das Material zum Ausbilden des Bauteils (11) ein Legierungspulver auf Eisenbasis ist.
5. Ein Verfahren zur Herstellung eines Synchronisationsrings (10) nach irgendeinem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß das Material zum Ausbilden des Bauteils (11) ein Legierungspulver auf Kupferbasis ist.
6. Ein Verfahren zur Herstellung eines Synchronisationsrings (10) nach irgendeinem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß das Material zum Ausbilden der Reibschicht (12) ein sinterbares Pulver, wie z. B. ein Pulver aus Kohlenstoff, Metall oder Harz ist.
7. Ein Verfahren zur Herstellung eines Synchronisationsrings (10) nach irgendeinem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß das Material zum Ausbilden der Reibschicht (12) sinterbare Fasern, wie z. B. Kohlefasern, enthält. 30

#### Revendications

1. Procédé de fabrication d'un anneau de synchronisation (10) comprenant une partie structurelle annulaire (11) et une couche de frottement (12) formée sur ladite partie structurelle annulaire, ledit procédé comprenant les étapes consistant à : 40

emplir un moule (20) à l'aide d'un matériau destiné à former la partie structurelle (11), ou d'un matériau destiné à former la couche de frottement (12), et compacter ledit matériau dans le moule ;

emplir le moule (20) à l'aide d'un matériau destiné à former la couche de frottement (12), ou d'un matériau destiné à former la partie structurelle (11), et compacter ledit matériau dans le moule afin de solidariser la partie structurelle (11) et la couche de frottement (12) ; et fritter simultanément la partie structurelle (11) et la couche de frottement (12) solidarisées. 50 55

2. Procédé de fabrication d'un anneau de synchronisation (10) comprenant une partie structurelle annulaire (11) et une couche de frottement (12) formée sur ladite partie structurelle annulaire, ledit procédé comprenant les étapes consistant à :
- emplir un moule (20) à l'aide d'un matériau destiné à former la partie structurelle, et d'un matériau destiné à former la couche de frottement (12) ;
- compacter lesdits matériaux dans le moule ; et
- fritter les matériaux, dans le moule, en faisant circuler une impulsion de courant par lesdits matériaux compactés.
3. Procédé de fabrication d'un anneau de synchronisation (10), selon la revendication 1 ou 2, dans lequel la densité ou la qualité du matériau compacté, destiné à former la partie structurelle (11), est modifiée en fonction de positions radiales occupées dans la partie structurelle.
4. Procédé de fabrication d'un anneau de synchronisation (10), selon l'une quelconque des revendications 1 à 3, dans lequel le matériau destiné à former la partie structurelle (11) est une poudre d'un alliage à base de fer.
5. Procédé de fabrication d'un anneau de synchronisation (10), selon l'une quelconque des revendications 1 à 3, dans lequel le matériau destiné à former la partie structurelle (11) est une poudre d'un alliage à base de cuivre.
6. Procédé de fabrication d'un anneau de synchronisation (10), selon l'une quelconque des revendications 1 à 5, dans lequel le matériau destiné à former la couche de frottement (12) est une poudre apte au frittage, telle qu'une poudre de carbone, de métal ou de résine.
7. Procédé de fabrication d'un anneau de synchronisation (10), selon l'une quelconque des revendications 1 à 5, dans lequel le matériau destiné à former la couche de frottement (12) renferme des fibres aptes au frittage, telles que des fibres de carbone.

50

55

Fig. 1A

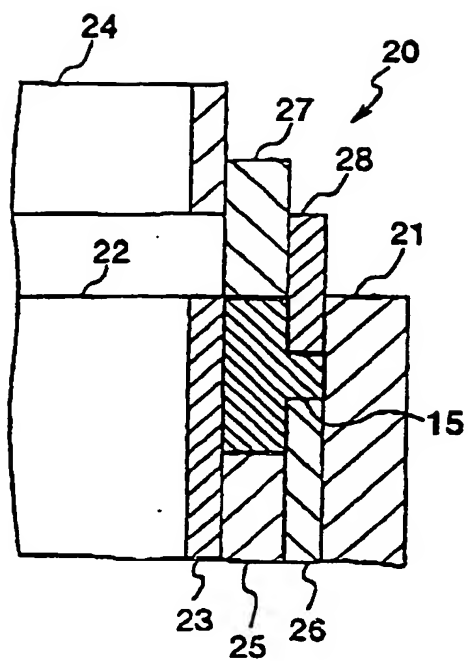


Fig. 1B

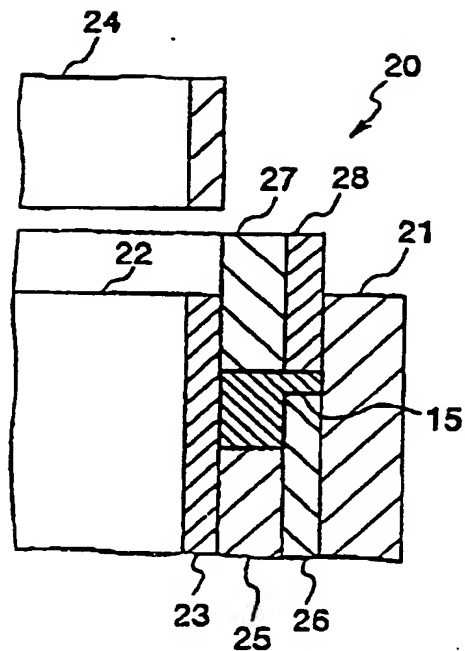


Fig. 1C

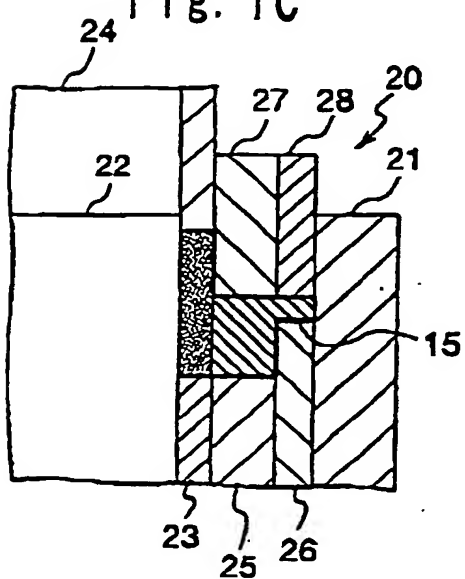


Fig. 1D

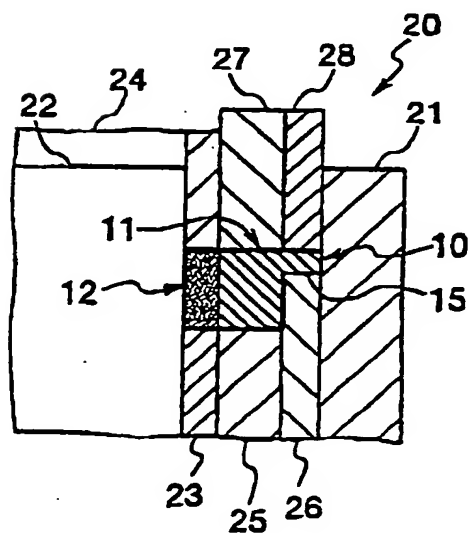




Fig. 2

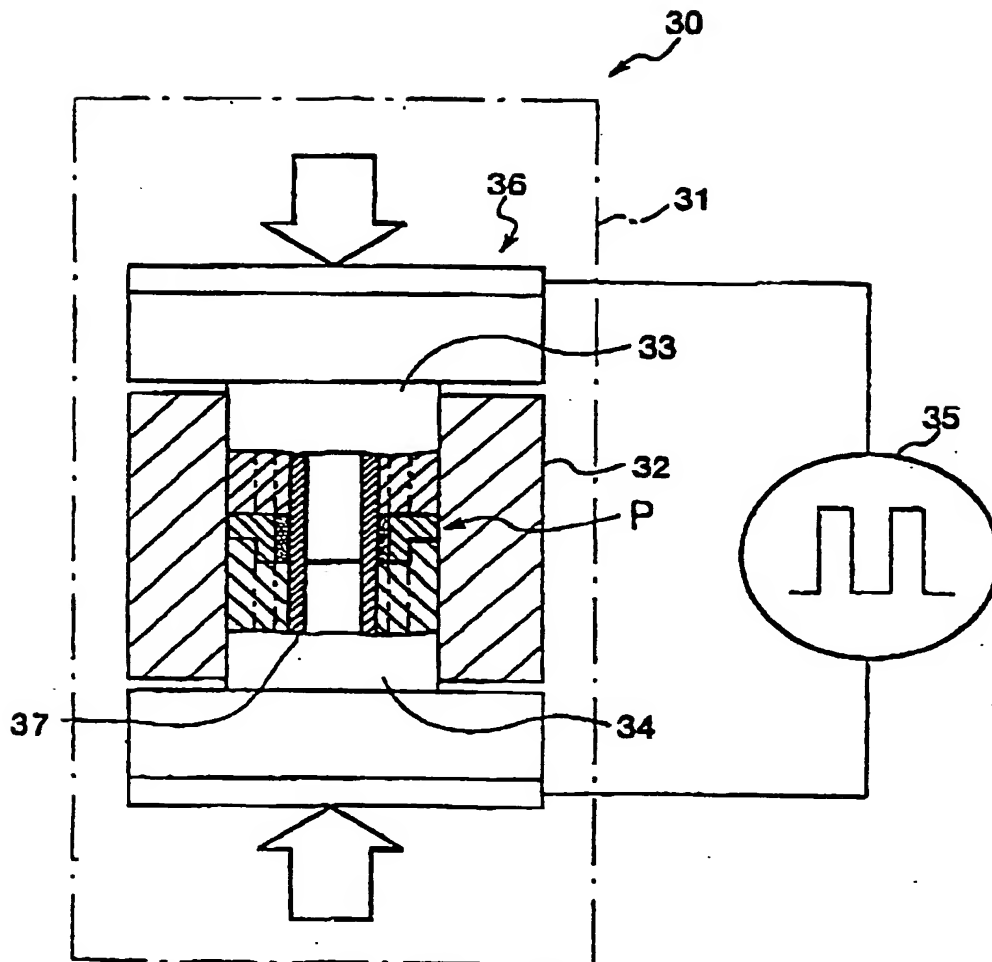


Fig. 3

